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how to control a GULLY

FARMERS' BULLETIN 2171 • U.S. DEPARTMENT OF AGRICULTURE

Gullies occur in every section of the country. The extent of damage they cause depends on climate, topography, geology, soil type, and land use. Gullies that have developed over the ages through the process of natural or geologic erosion are a part of the general configuration of the landscape. But many gullies are created by accelerated erosion resulting from man's misuse of the land. These are the gullies that usually do the greatest damage; they are the kind of gullies that can and should be controlled.

Uncontrolled gullies on farmland and rangeland may advance to the point where they cut up fields or whole farms so they must be abandoned. Sediment from eroding gullies deposited on bottom land may destroy its value. Sediment trapped in reservoirs and deposited in stream channels creates large economic losses. Gullies may drain areas enough to reduce crop production. In some areas deep gullies may lower the ground-water table. Gully erosion and resultant sedimentation increase the cost of maintaining highways, railroads, pipelines, and other public utilities. Therefore, control of gullies is a highly important phase of soil and water conservation.

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How To Control a Gully

By C. J. Francis, *Director, Engineering Division, Soil Conservation Service*

THE best way to control gullies is to prevent their formation. A good conservation plan put into effect before an extensive system of gullies has formed insures protection against gullies. It also may transform many gullies into good vegetated waterways and increase farm values.

Proper Water Disposal Prevents Gullies

A system for disposing of water is necessary on all farms and ranches on which runoff occurs. It should provide for control of runoff and erosion so that gullies will not form.

The natural processes of erosion have created natural drainage patterns. The runoff from fields and within fields is collected in these natural drainageways and carried to main-stream channels.

A good conservation plan uses the natural waterways to carry runoff from individual fields and farms. The waterways are shaped where necessary to provide a channel having sufficient capacity to carry the expected runoff at nonerosive velocities.

The channels are maintained in grass. During the plowing and cultivation of fields, equipment is raised when crossing the waterways so as not to damage them or reduce their capacity. Grass seed and forage may be harvested from the waterways. Often they can be grazed to good advantage.

ILL-809

Gully erosion was stopped on this Illinois farm by converting the natural drainageways to grass waterways. Hay is being harvested from the waterways.

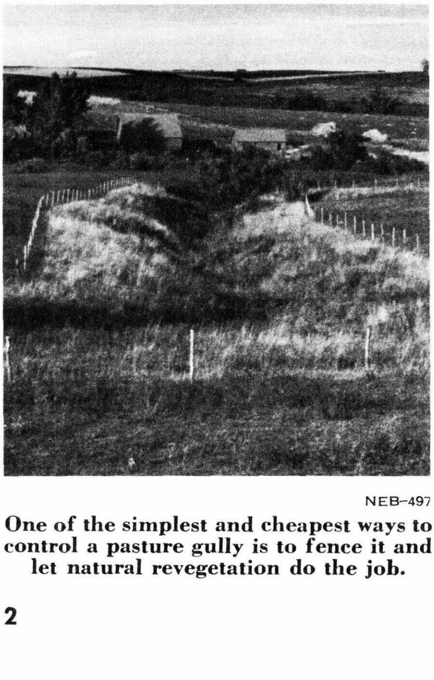
Control Methods Depend on Size

Gullies that have developed can be stabilized or improved to serve as adequate water-disposal systems. The cost of repairing a gully generally is proportional to its size. Some gullies have been allowed to advance to the point where it does not pay to repair them.

A small gully is considered to be less than 8 feet deep, a medium gully 8 to 15 feet deep, and a large gully more than 15 feet deep. The drainage area—that is, the area draining into a gully at any given point—also affects the type of control that may be used. Gullies whose drainage areas cover less than 50 acres are considered to have a small drainage area. Drainage areas of 50 to 150 acres are considered medium sized. Drainage areas greater than 150 acres are large.

The measures used to control, improve, or obliterate gullies depend on the size of the gully and its drainage area.

Small gullies with small to medium drainage areas are the ones that can best be improved and controlled by a farmer or rancher.



NEB-497

One of the simplest and cheapest ways to control a pasture gully is to fence it and let natural revegetation do the job.

ALA-D10-4

Small gullies, like this one in Alabama, can be controlled and improved by fairly simple conservation-farming practices.

Natural Revegetation

One of the simplest and cheapest ways to arrest the advance of small- to medium-sized gullies having small drainage areas is to fence them and exclude livestock—a common procedure in areas that are gullied badly and cannot feasibly be restored to cropland.

The fence should completely enclose the area to be controlled. It should be placed far enough from the banks of the gully to allow a good growth of vegetation to form. A good rule is to set the fence back from the edges of the banks a distance about equal to twice the gully depth.

Planting Trees or Grass

Once the area is fenced, natural revegetation often will give adequate protection, but natural revegetation usually is a slow process. Grass, shrubs, or trees used separately or in combination give good results. If natural growth does not give adequate control or if the farmer wants a particular type of vegetation, the gully should be planted.

When trees are used, the process of control can be speeded up by planting adapted species.

It is hard to give a complete list of adapted species to cover all sections and conditions, but the following list is suggestive:

Northeast: Eastern redcedar, Scotch pine, red pine, pitch pine.

Middle Atlantic States: Eastern redcedar, red pine, Scotch pine, Virginia pine, shortleaf pine, pitch pine.

Southeast: Shortleaf pine, Virginia pine, eastern redcedar, loblolly pine.

Northern Great plains: Red pine, eastern redcedar, willow, elm, poplar.

Southern Great Plains: Eastern redcedar, incense-cedar, poplar, willow.

Northwest: Ponderosa pine, Scotch pine, Douglas-fir, poplar.

Southwest: Ponderosa pine, incense-cedar, poplar, pinyon.

Mountain States: Ponderosa pine, Douglas-fir, Scotch pine.

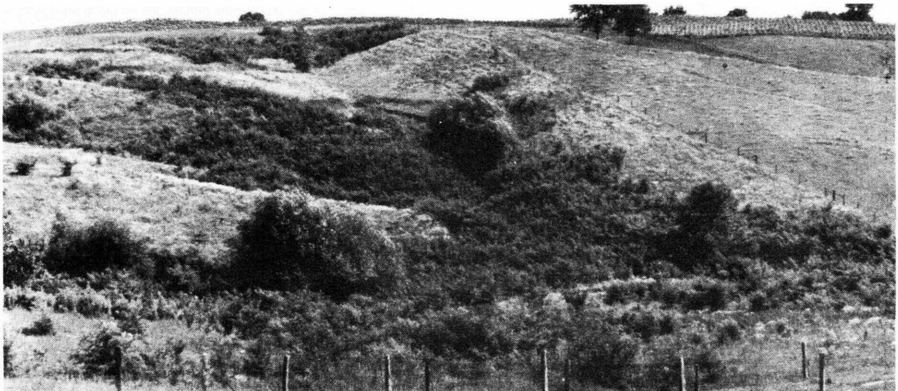
If grass is planted in a gully, adapted species should be used. There are several adapted species of grass for almost any situation. Native grasses will be better suited to gully plantings in most cases.

When a gully is planted, it may be necessary to do some bank sloping to permit successful planting or seeding of steep areas. Usually a satisfactory growth can be established without extensive sloping.

When a gully is to be retired to wood-

IA-208-A; IA-208-B

The gullied area in Iowa (above) was fenced and planted to trees. After 2 years' growth the trees and other vegetation had healed the gully scars (below).



lot or grass and stabilization is the primary factor, only a little bank sloping should be done.

Diversion of Runoff

Diverting runoff away from a gully head is an effective control measure. Water may be diverted away from a gully by a diversion ditch or by a series of terraces or contour furrows.

The use of diversions is limited to small drainages because of the difficulties in handling large volumes of water. A diversion can be used only where there is a satisfactory outlet. If the outlet is subject to erosion, the water should not be diverted. No advantage comes from diverting water from one gully if there is danger of forming another.

Diversions are best used in connection with small gullies in pastures in which satisfactory outlets are common.

The areas above a diversion should be in grass or woods to reduce siltation in the channel. Diversions below cultivated fields may silt rapidly and create maintenance problems. The diversion should be set upstream from the head of the gully a distance not less than three to four times the depth of the gully.

A diversion is like a terrace, except that it normally is larger. It should be large enough to carry the runoff from the heaviest storm that is likely to occur about once in 10 years. A velocity of 4 to 6 feet a second normally will protect the channel from erosion when a good stand of grass is established. A grade of 6 to 12 inches per 100 feet usually is safe. After water is diverted from a gully, natural revegetation may provide adequate control.

Where terraces or contour furrows are used, runoff into gullies may be reduced to the extent they will become stable through natural revegetation.

Level terraces and contour furrows should be applied to the major part of the area draining into the gully. Level terraces properly spaced to control erosion and conserve water should reduce runoff enough to provide control for most gullies. The spacing and water-holding capacity of contour furrows depend on their purpose.

Contour furrows built solely to improve range or pastureland may not

IA–2707

The owner of this Iowa field built terraces above some gullies that were forming near the center of the field. Runoff is now diverted away from the gullied area to grass waterways at the ends of the terraces.

store enough runoff to be wholly effective in controlling gullies.

Ponds in Gullies

Development of stockwater ponds in range sections or pastures may help to solve gully problems. A dam built near the head of a gully or in a gully may store a large part of the runoff. The storage of water behind a dam reduces runoff downstream, and the reduction in runoff may permit natural revegetation to control erosion for a reasonable distance below the dam.

Changing Gullies to Grass Waterways

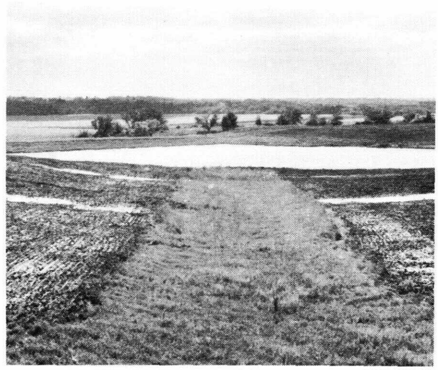
Natural drainageways that are gullied or have an improper cross section can be improved to carry the runoff safely.

A practical way to transform a gully into a satisfactory waterway is to shape it and seed it to adapted species of grasses. This method is best adapted to small and medium gullies that have small to medium drainage areas. A properly shaped earth channel with good vegetative cover will carry the runoff from the average farm or field without causing erosion.

If a vegetative waterway is to function effectively, the velocity of flow should be about 3 to 6 feet a second, depending on the kind of soil and grasses used. The channel cross section should be broad and flat to keep the water spread uniformly over a wide area.

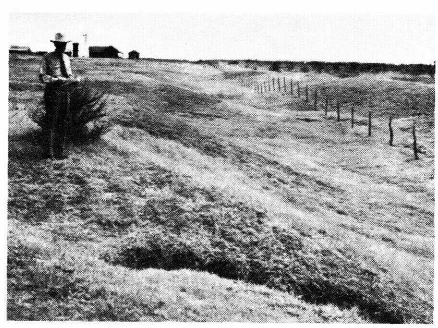
Usually the depth of flow in a vegetated channel should be about 6 to 18 inches, depending on the slope, in order to keep velocities within reasonable limits. The slope of the channel—that is, the drop per unit of length—normally should not exceed 10 feet per 100 feet. Steeper slopes usually cause the water to flow too fast to maintain a good vegetative cover.

One cannot give a simple rule for determining the velocity of flow for a specific cross section and given slope.



KAN-1798

The owner of this Kansas farm converted a gully to a grass waterway with a pond at the lower end. Terraces empty into the waterway.



TEX-40,282-A; TEX-40,282-B

The pasture gully (above) was shaped and seeded to grass (below) and now serves as a waterway.

ARK-61-487-A; ARK-61-487-B

This gullied area in Arkansas (above) was shaped and planted to grass (below). It will serve as a farm waterway as soon as the grass is well established.

However, one point to remember is: As the slope of the channel increases, the depth of flow must decrease to maintain velocities in reasonable limits.

Because vegetated channels cannot be constructed to precise dimensions, it is hard to maintain flow at shallow depths uniformly over wide areas. Therefore the maximum width of waterways rarely should exceed 100 feet. It is advantageous to divide the waterway into two parallel channels when greater widths are required. This can be done easily by constructing a small ridge of earth down the center of the proposed channel. Each waterway is then planned and built as one unit.

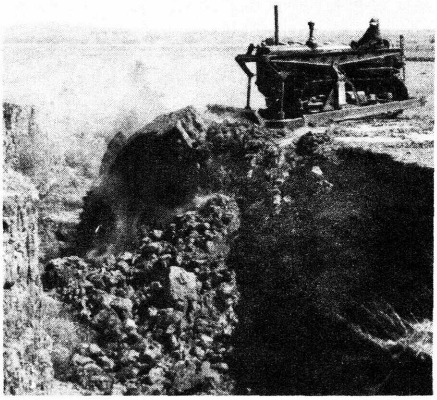
Vegetated waterways carry runoff without erosion when the runoff lasts a short time and flows at reasonable velocities.

A waterway should not remain wet over long periods. Continued wetting may kill desirable vegetation. It softens the soil to the extent that the vegetation is not effective in protecting the soil when stronger flow occurs.

Melting snow and resultant runoff in northern sections may cause flow for long periods and should be considered in planning a waterway.

As the size of the drainage area increases, the duration and volume of flow increases. Therefore vegetated waterways having drainage areas larger than 150 to 200 acres usually are not successful.

Because natural waterways occur at elevations below the level of the adjoining field, seepage may cause the area to be wet and boggy. A tile drainage system may then be required. A proper system of drainage will remove ground water to the extent required to dry up the waterway and make it work.



OKLA-5448

A bulldozer is being used to start shaping operations on this Oklahoma gully. After shaping, the gully will be planted to grass.

MINN-1710

Shaping operations on this Minnesota waterway are nearing completion, while SCS technicians check the grade and shape.

Shaping and Seeding Waterways

The first thing to do in changing a gully to a grass waterway is to shape the gully to the desired size and form needed for the waterway.

Gullies can be shaped with heavy earthmoving equipment or with the power equipment that is available on the farm. Small gullies can be shaped with a farm tractor and plow. They can be filled gradually by plowing around the gully, starting near the edge of the bank and working the earth toward the center. A series of rounds, as is used in building a terrace, by working the earth toward the center of

the gully, gives good results. Considerable working of the soil may be required to provide for a smooth, regular cross section. A blade, scraper, or harrow are good pieces of equipment for doing that. A little experience soon develops the plowing pattern that gives best results.

Heavy earthmoving equipment—especially the track-type tractor and bulldozer and the motor patrol—is well suited to filling gullies. Either unit can push the dirt into the channel efficiently. The blade, an integral part of each unit, is suited to finishing operations. The heavy equipment packs the earth during filling operations and reduces settling to a minimum. Uncompacted earth settles; in deep gullies it might settle enough to distort the shape of the channel. Compaction also increases the erosion resistance of the earth in the channel—an important item particularly during the time vegetation is being established.

A firm seedbed should be prepared when the gully has been shaped to the desired cross section. The channel area should be fertilized because much of the topsoil may have been removed in filling operations. Grass then is seeded in the usual way. A good mulch cover is helpful in obtaining a good stand.

Some of the grasses best adapted for use in waterways are: Midwest and Northeast—bromegrass, redtop, and bluegrass; reed canarygrass (well suited for wet waterways); tall fescue (adapted to southern one-third to one-

IA-2098

This Iowa farmer is careful to lift the cultivator as he crosses the grass waterway during tillage operations.

KAN-1722

This grass waterway in Kansas was established before the terraces were built. It now handles the runoff from the terraces seen in the background.

half of area). Southeast—tall fescue, bermudagrass, and Pensacola Bahia grass. Great Plains and Northwest—intermediate wheatgrass, western wheatgrass, buffalograss. Southwest—switchgrass, Indian grass, bluestems, western wheatgrass, buffalograss; tall fescue and bermudagrass in the more humid parts.

Protecting New Waterways

As the channel may erode while grass is getting started in a waterway, a temporary diversion should be built to divert water away from it. Later it can be removed with a plow or scraper. If it is difficult to keep water out of the channel, a companion crop should be planted to give protection during the establishment stage.

Waterways used to carry water from terraces and diversions should be shaped and seeded and a good growth of vegetation established before the terraces or diversions are built.

Structural Control

Vegetation cannot be used to stabilize all types of gullies. The determination of where vegetative measures become unsatisfactory and structural measures are required can only be made after a careful study of individual site conditions. Structural measures consist of dams of varying design constructed for the purpose of stabilizing the grade and halting further erosion. Properly installed structures will transform an unstable gully into a satisfactory waterway.

MO-1939

The owner of this Missouri farm found it necessary to build a permanent drop-spillway structure to stabilize the lower end of his grass waterway.

Temporary Structures

Many types of temporary structures —brush dams, log dams, wire dams, rock dams—have been used to stabilize gullies while vegetation is being established. They involve much hand labor and are costly considering their short period of usefulness. Their value is doubtful. Temporary structures therefore are not generally recommended.

Permanent Structures

Permanent structures usually are built of reinforced concrete or masonry or of earth with concrete or steel pipe spillways.

Permanent structures generally are used in medium to large gullies with medium to large drainage areas. Vegetation usually is not successful in controlling such gullies. Structures require the use of materials that must be purchased. Often special equipment and skilled labor must be used to build them. Permanent structures therefore are relatively costly. They should be built only after engineering studies and adequate plans have been made.

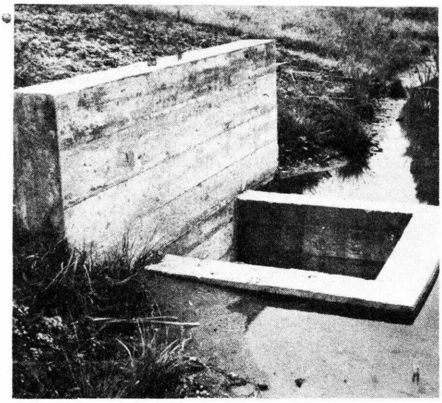
The main purposes of a permanent structure are to halt the advance of the vertical overfall at gully heads, stabilize the grade so the gully can be used as a waterway, and reduce the flow downstream when spillway storage is provided. In stabilizing the grade of a gully, structures trap sediment and eventually cause filling of the gully. If one wants to speed the filling process, the raw gully banks above and between structures can be shaped at the time of construction.

Three basic structures are used in stabilizing gullies: The drop inlet, drop spillway, and chute. Each is adapted to specific conditions, and the selection of one or another can be determined only by an engineer after examining the site and deciding which will satisfy the requirements best.

Because the permanent structures must have a stable grade downstream, it often is necessary to build several structures in a reach of gully to stabilize it. A grade is stable when the channel is neither agrading or degrading. Stability depends on the kind and amount of vegetation in the channel, the soil material of which the channel is composed, and the velocity of the running water. A dam in a gully traps most of the sediment that would normally pass downstream. This loss of sediment may cause a grade that seems to be stable to start eroding, particularly when the channel is in sandy soil.

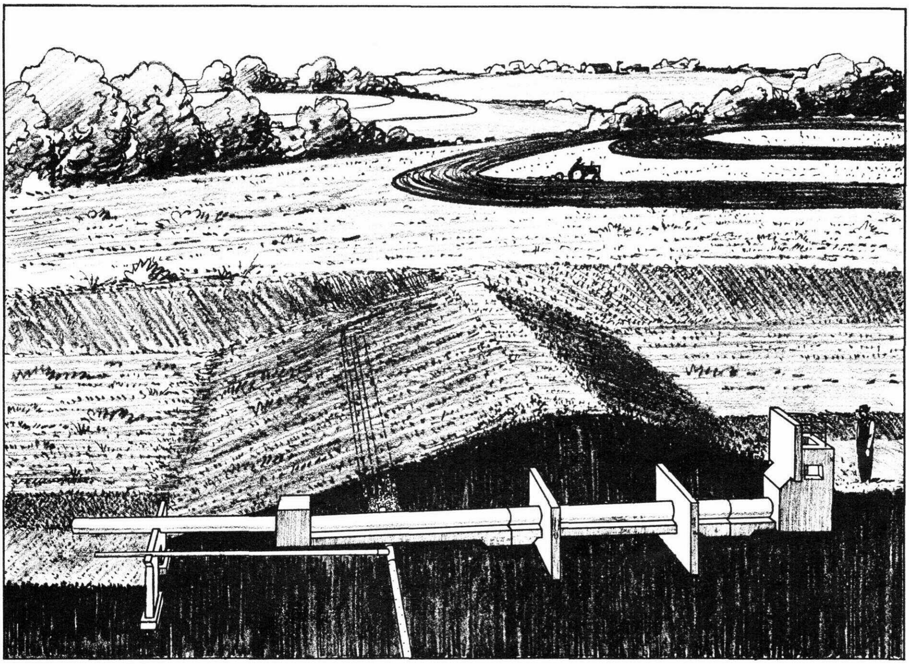
A structure built to protect head erosion must be located so that the grade from the spillway crest to the ultimate lip of the gully will not exceed the silting grade. The safest procedure is to build the dam high enough to make the crest of the spillway level with the lip of the gully. The silting grade depends on the nature of the soil. It is best determined by investigating the grade of gullies in the area that appears stable. As a general rule, the silting grade should be kept within the limits of 6 inches per 100 feet.

The most important factor affecting the safety of a structure is the capacity of the spillway. The spillway should safely discharge the runoff from the heaviest rainfall that can be expected



CONN-97

This drop-inlet structure serves to stabilize a gully and to collect sediment that had been accumulating on a field below.



SS-6

Drop inlet with a propped outlet built through an earthfill dam.

once in 25 to 100 years, depending on the importance of the structure. For example, if the structure is relatively small and inexpensive, the spillway should be designed to pass a flood that will occur once in 25 years.

Drop Inlets

The drop-inlet dam is ideally adapted for grade stabilization or control of advancing gully heads when the gully is more than 10 feet deep.

It consists of an earth dam with a drop-inlet spillway of concrete or metal pipe. The spillway has a vertical section on the upstream side of the dam, called the riser, which is connected to a culvert or barrel passing through the earth dam. The crest of the riser is set at the elevation required to stabilize the grade upstream or to protect the gully head. Water must rise to the top of the riser before it discharges downstream.

Usually an earth emergency spillway is built around one end of the dam to take the infrequent high flood flows. The spillway should be cut in the earth abutment and far enough away from the earthfill so there is no danger of the floodflow coming in contact with the downstream slope of the fill. The spillway grade should be flat enough that vegetative cover may be established to protect it against erosion.

By building the dam high enough to temporarily store some floodwater and installing an emergency spillway, the size and cost of a drop-inlet structure may be reduced. The cost of passing the total floodflow through a drop inlet may be so great that the structure will become uneconomical.

The emergency spillway should have a good cover of vegetation, a uniform cross section, a gradual slope to the channel downstream, and no abrupt turns. It is primarily for the purpose of safeguarding the structure under extreme flow conditions at a reasonable

KY-675

A concrete drop spillway constructed to stabilize the grade in a small gully.

cost. The emergency spillway should be enough higher than the crest of the drop inlet to permit the drop inlet to discharge at its rated capacity before the emergency spillway functions.

The outlet of the drop inlet is placed at or slightly above the elevation of the grade below the structure.

A propped outlet is generally used. The pipe is extended about 8 feet below the toe of the dam and is supported by piling or a concrete pier. The support is placed 6 to 8 feet from the end of the pipe to protect it from the scour hole that will form. The advantage of the propped outlet is its low cost and its ability to discharge water far enough downstream so as not to endanger the safety of the structure. If the grade lowers excessively downstream from the outlet, the outlet can be extended and lowered at a reasonable cost. A propped outlet permits installing structures at locations where the grade downstream is not considered completely stable.

As a general rule, a drop inlet with a propped outlet should not be built where the grade downstream averages more than 1 percent. In places where grades are steeper, supporting structures should be built downstream to a point where the resultant grade is less than 1 percent.

The preparation of the foundation and placement of earthfill for drop-inlet structures is carried out in accord with standards covering the construction of earthen embankments. These standards, which are based on long experience, can be obtained from the local office of the Soil Conservation Service.

Drop Spillways

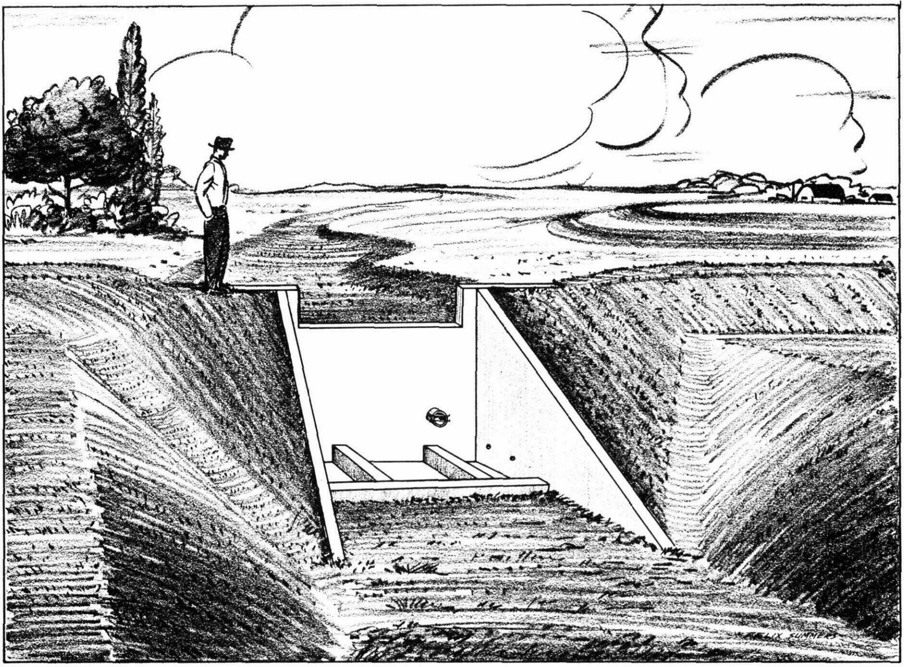
Drop spillways are built of reinforced concrete, masonry, or sheet steel piling. They are somewhat like the old mill dams built in small streams to serve as a source of power. Because dams in dry draws are not subject to continuous flows, the drop spillway is simpler in design and of lighter construction. It can be designed for almost any height, but it is best adapted to drops of 10 feet or less. The total storm runoff usually passes over the crest of the drop spillway. Emergency earth spillways are seldom used in connection with drop spillways.

Drop spillways require careful design of the apron or floor, on which the water falls, to dissipate the energy before passing to the channel below. Improper apron designs cause scour of the channel immediately below the structure. Excessive scour immediately downstream endangers the safety of a structure. Drop spillways therefore are used only at places where the grade downstream from the structure has been carefully studied and determined stable. Earthfills are used to connect the structures with the earth abutments.

Chutes

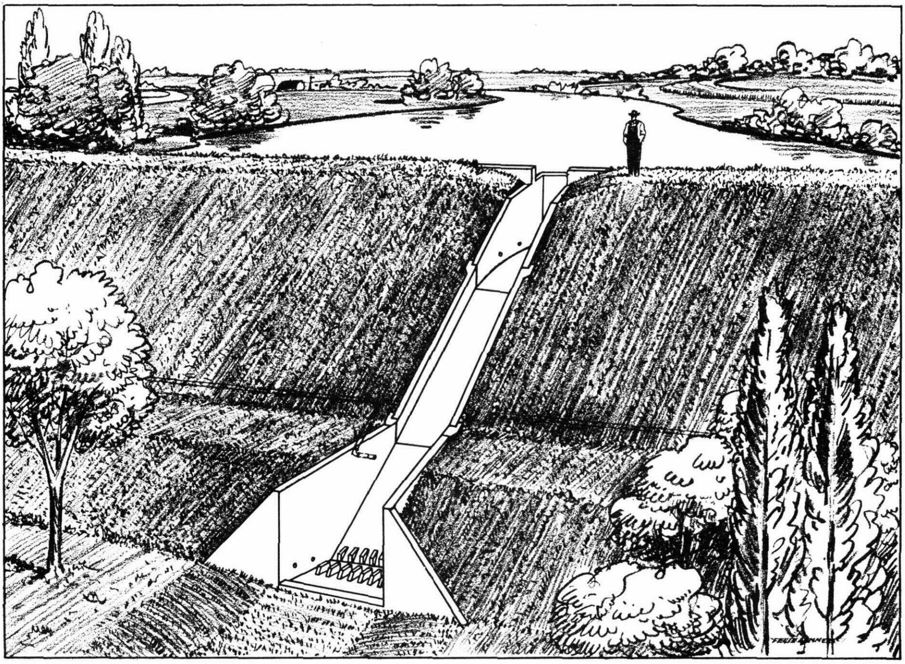
Chutes are used in combination with earth dams to drop water farther than is ordinarily feasible with drop structures. They are built of reinforced concrete.

Chutes should be constructed on foundations on original ground or on fill that has been carefully compacted under controlled conditions. The chute is susceptible to movement because of frost action or other causes. Closely spaced expansion joints are



SS-1

Drop spillway built to stabilize the lower end of a grass waterway.



SS-5

Chute spillway in a fairly large earthfill dam.

MINN–1734

A combination gully-control and floodwater-retarding structure was built across this large gully in Minnesota as a part of a watershed-protection program.

required to relieve the structure of stress that would cause cracking. Chutes are individually designed to fit specific site conditions.

Engineering Services Needed

Structural control of gullies usually requires the service of an engineer to insure an economical, safe job.

The sizes and costs of the structures required to control a gully or system of gullies vary widely. Structural improvement of waterways generally requires a sizable outlay of money.

Standard plans have been developed and can be used successfully when properly adapted to site conditions. The plans are usually confined to drop spillways that have a height of 5 feet or less and to small drop inlets that have a total height of fill less than 15 feet.

These small structures can usually be built by a farmer with technical assistance. Whenever he considers structural or vegetative control of a gully he should get in touch with the Soil Conservation Service or the Extension Service to find out the technical services that are available.

Most vegetative-control measures can be wholly or largely carried out by an individual farmer. For structures, an engineering survey must be made, detailed plans must be prepared, and construction must be carried out by skilled individuals under careful supervision. Good materials and safe designs are essential for satisfactory permanent structures.

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